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Radiography and Ultrasonic Calculation Workbooks: Installation and Use

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U.S. Department of Energy
Lawrence Livermore National Laboratory

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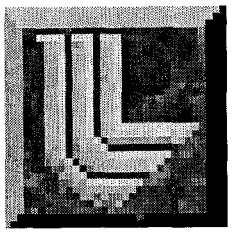

Radiography and Ultrasonic Calculation Workbooks: Installation and Use

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Background

The radiography and ultrasonic calculation workbooks are intended to assist Level I, II and III NDE personnel in calculations used in routine job applications. These workbooks are an upgraded version of Microsoft Excel® spreadsheets, which were originally set up in October 1988, using a Macintosh Plus® computer and Microsoft Excel® version 1.5. A description of these was released as "Computerized Calculations for Radiography and Ultrasonics", UCRL-JC-105419 in November 1990 and published in Materials Evaluation, Volume 49/ Number 4, in April 1991. Over the years as Microsoft improved the capabilities of the Excel program to include the abilities to make sketches and to have multiple tabbed pages in a document called a "workbook", we have now modified the calculation spreadsheets to include these enhancements.

Following is a short description on how to install and use these workbooks on a Macintosh or PC.

RT Workbook Installation

Drag the "RT Workbook" icon onto your desktop or into the folder where you want the icon to reside. Double click the icon to open it. On the Macintosh, If the workbook is locked, it will display the message illustrated in Figure 2. Click on "OK" to open the workbook. The workbook will operate the same whether it is locked or unlocked, but it is recommended that the workbook after installation be locked to prevent accidental changes to the formulas in the calculation cells.

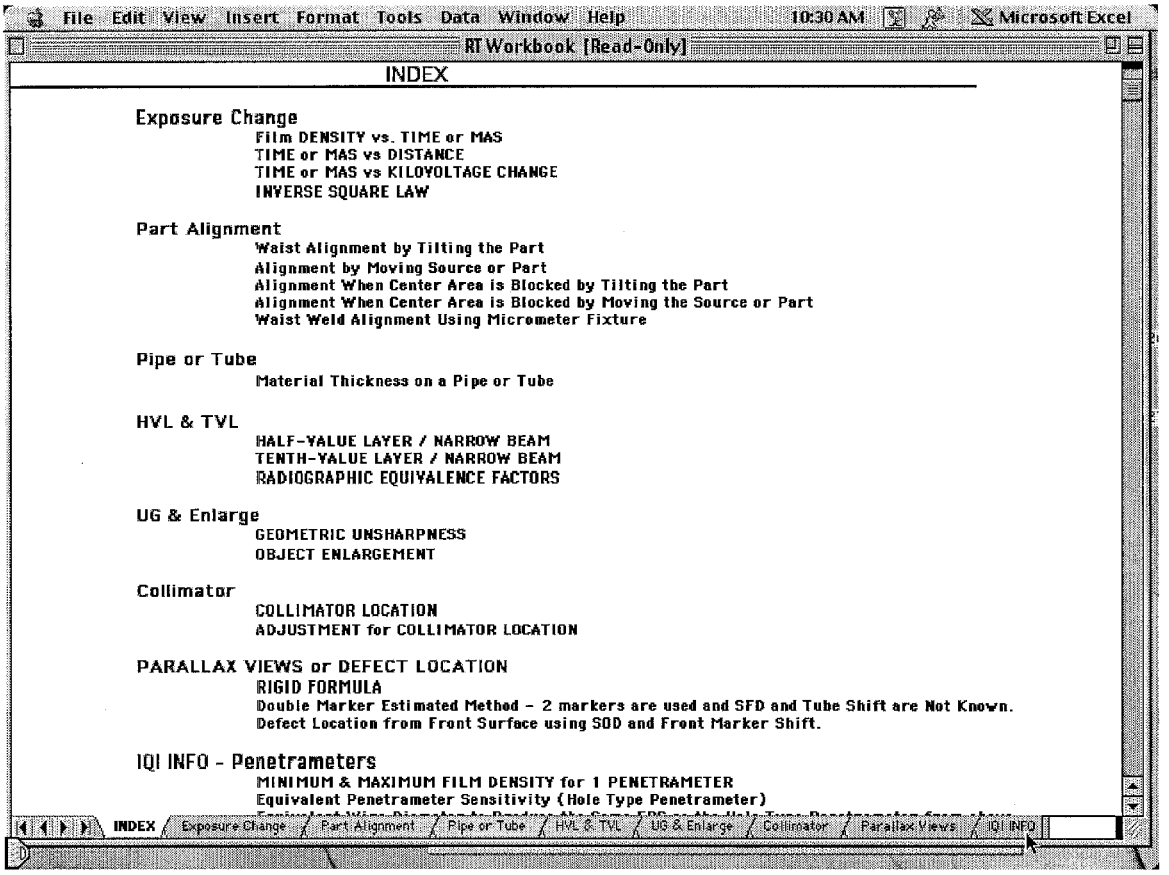

Figure 1

Figure 1 shows how the Index page should look on your computer screen. If the page tabs along the bottom edge of the workbook or the scroll bar on the right side of the window is not visible on your computer screen; you must arrange the window. The workbook must be unlocked to do this. To unlock the workbook, close the workbook then click the mouse once on the icon to select it. The icon will then turn black.

On the Macintosh go to File on the Menu bar, go to Get Information, then click the mouse on the Locked box on the lower left side of this window. The checkmark in this box will disappear and the file will be unlocked.

On a PC to unlock the workbook, go to Tools in the Menu bar, go to Protect Workbook then click the mouse on Protect Structure and Protect Windows to delete the checkmarks. The file will now be unlocked.

Double click the mouse on the icon to open the workbook. The locked warning in Figure 2 should NOT BE DISPLAYED when the window opens.

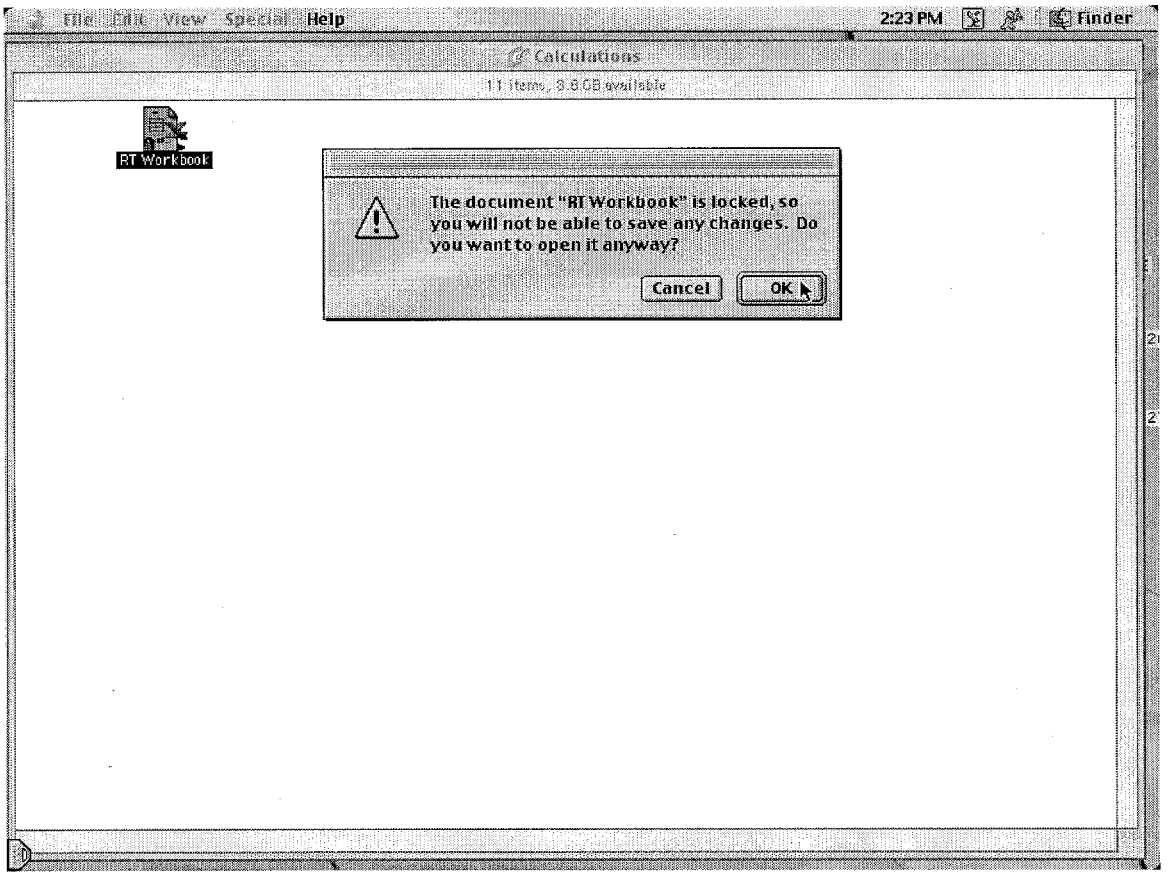

Figure 2

Arrange the window on a Macintosh or a PC by pressing the mouse on Window in the Menu bar, drag the cursor down to Arrange All, click the mouse on Tiled then click on "OK". The workbook should now look like Figure 1. The Scroll bar on the right side of the page is used to scroll up and down the pages and the tabs along the bottom edge of the workbook are used to go to the individual calculation pages.

The workbook should now be locked.
On the Macintosh to lock the workbook you should have it saved with the Index page displayed as it is in Figure 1. Go to File on the Menu bar, go to Get Information and click the mouse on the Locked box on the lower left side of this window. A checkmark will appear in the box. With the workbook saved and locked in this manner it will always open on the Index page. If a formula is accidentally changed, it will not be a permanent change; the next time the workbook is opened, it will revert back to the original formula.
Each time the workbook is opened after being locked, the message in Figure 2 is displayed. Click the mouse on "OK" to continue.

To Lock the workbook on a PC you should have it saved with the Index page displayed as it is in Figure 1. Go to Tools in the Menu bar; drag down to Protection, then to Protect Workbook. Click the mouse on Protect Structure and Protect Windows. Checkmarks will appear in these boxes.

UT Workbook Installation

Drag the "UT Workbook" icon onto your desktop or into the folder where you want the icon to reside Double click the icon to open it. On the Macintosh, if the workbook is locked, it will display the message illustrated in Figure 2. Click on "OK" to open the workbook. The same procedure as previously described should be used to arrange and lock the "UT Workbook". This workbook does not have an Index and has only a single page of formulas so only the scrollbar on the right side is used to find the appropriate calculation.

RT Workbook Operation

From the Index page in the "RT Workbook" an individual page is used for the different calculations necessary. For example, if you want to calculate where to place a 4" diameter collimator to obtain a 5" diameter field of view when using a source-to-film distance of 12 feet (144"), the following steps would be taken: 1) On the Index page in Figure 1 you see Collimator Location is on the Collimator page, so click the mouse on the Collimator Tab on the bottom edge of the workbook. 2) The mouse click will immediately go to that page. 3) Enter the parameters in the boxes provided for Source to Film Distance (144), Size of the Collimator Image on the Film (5) and the Collimator Hole Diameter (4). Press the Enter key or click the mouse in another cell outside of these boxes and the answer will be calculated and displayed in the left column. A source-to-collimator distance of 115.20 inches would be needed to obtain this field of view (see Figure 3). After you have finished with your calculations and want to quit the workbook, do not save the changes in the workbook by clicking the mouse on the Don't Save button.

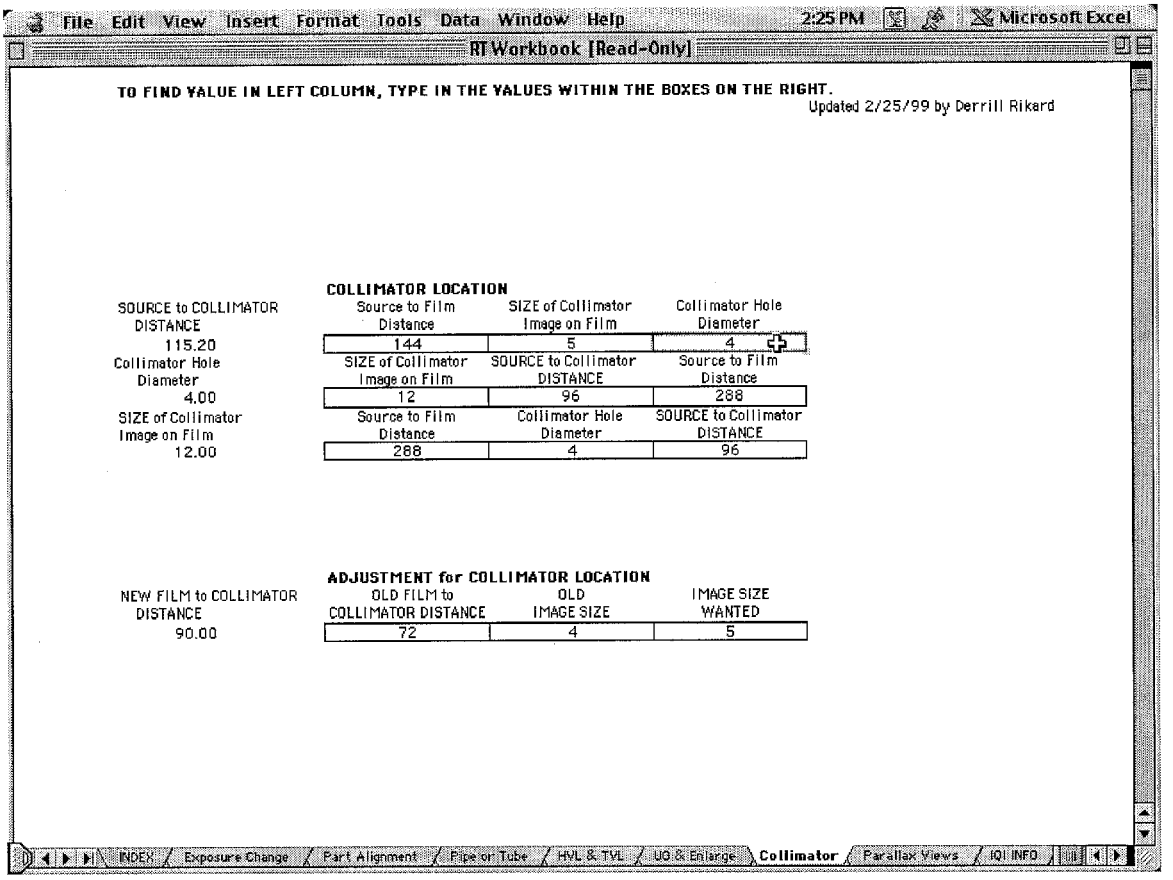

Figure 3

UT Workbook Operation

The same procedure as previously described should be used for calculations in the "UT Workbook". However, this workbook does not have an Index page and has only a single page of formulas so the scrollbar on the right side of the page is used to move up and down the page to find the appropriate calculation.

Summary

These worksheets have been in use for many years now with many modifications as Microsoft Excel has improved. This short description and example is to help new users install the latest versions and get started using them. Other useful calculations can be added to these workbooks but remember to Unlock the workbook before making changes.

Direct questions, comments and suggestions to Derrill Rikard, LLNL, P.O. Box 808 L-333, Livermore, CA. 94551-0808, Phone (925) 442-7947 or E-mail rikard1@llnl.gov

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TO FIND VALUE IN LEFT COLUMN, TYPE IN THE VALUES WITHIN THE BOXES ON THE RIGHT.

Updated 2/17/00 by Derrill Rikard

Film DENSITY vs. TIME or MAS

NEW time or MAS
1.14

Film DENSITY Wanted	First Film DENSITY	Old Time or MAS
2	1.8	1

TIME or MAS vs DISTANCE

NEW TIME/MAS
67.50

OLD TIME or MAS	OLD DISTANCE	NEW DISTANCE
30	36	54

TIME or MAS vs KILOVOLTAGE CHANGE

OLD KILOVOLTAGE	OLD TIME or MAS
50	1

Higher Kilovoltage	TIME or MAS @ Higher kV	Lower Kilovoltage	TIME or MAS @ Lower kV
60	0.5	42.5	2

INVERSE SQUARE LAW

INTENSITY 2
0.28

Intensity 1	Distance 1	Distance 2
150	1	23

DISTANCE 2
327.33

Intensity 1	Intensity 2	Distance 1
18000	0.168	1

INTENSITY 1
861.11

Intensity 2	Distance 1	Distance2
80	12	39.37

DISTANCE 1
43.00

Intensity 1	Intensity 2	Distance 2
2.38	2.38	43

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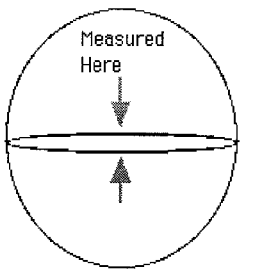
Updated 3/2/99 by Derrill Rikard

Waist Alignment by Tilting the Part

Degrees to Tilt the Part	Measured Part Diameter	Measured Gap (Misalignment)
0.895	8.000	0.125

If the tilt needed to align the part is done by measuring the distance from the present position to the aligned position, use the following calculation to determine where to mark the new position on the front side of the part.

Distance to the New Location	Measured Part Diameter	Measured Gap (Misalignment)	Actual Part Diameter
0.059	8.000	0.125	7.500



Alignment by Moving Source or Part

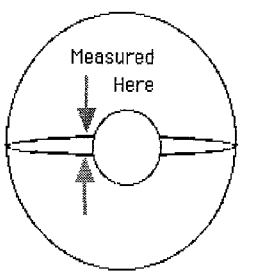
Distance to Move the Source or Part	Source to Object Distance	Measured Part Diameter	Measured Gap (Misalignment)
0.143	45.600	8.000	0.025

Alignment When Center Area is Blocked by Tilting the Part

Degrees to Tilt the Part	Measured Part Diameter	Distance from Part Edge to Measurement Location	Measured Gap (Misalignment)
0.902	8.000	3.500	0.125

If the tilt needed to align the part is done by measuring the distance from the present position to the aligned position, use the following calculation to determine where to mark the new position on the front side of the part.

Distance to the New Location	Measured Part Diameter	Distance from Part Edge to Measurement Location	Measured Gap (Misalignment)	Actual Part Diameter
0.065	8.000	3.000	0.125	7.500



Alignment When Center Area is Blocked by Moving the Source or Part

Distance to Move Part	Measured Part Diameter	Distance from Part Edge to Measurement Location	Measure Gap (Misalignment)	Source to Object in IN.
0.143	8.000	4.000	0.025	45.600

Micrometer Correction

0.027

Waist Weld Alignment Using Micrometer Fixture

Max. Gap Measurement	Part Diameter-INCHES	Micr.to Leveling AXIS
0.050	4.688	2.5

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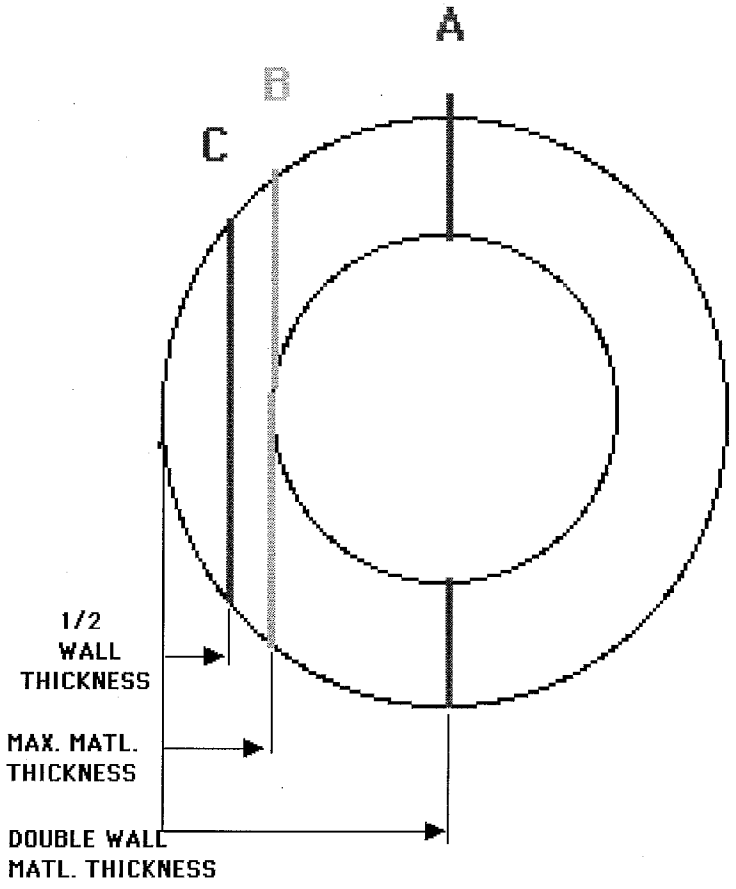

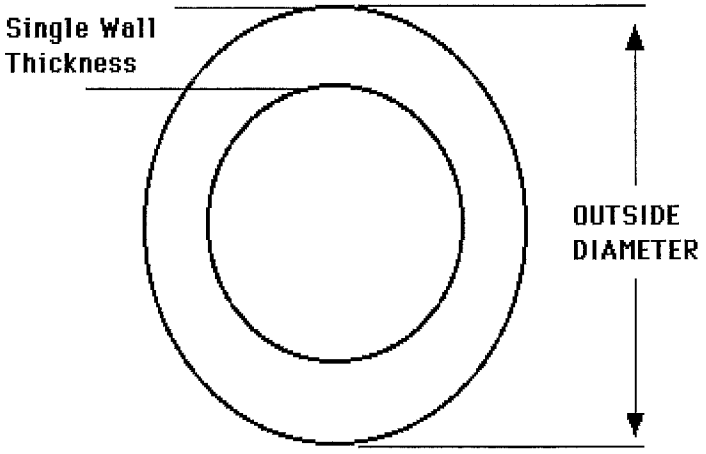

Material Thickness on a Pipe or Tube

Matl Thickness at Location A - Double Wall Thickness
0.052

Maximum Matl Thickness at Location B
0.101

Matl Thickness at the Center of the Wall - Location C
0.076

Outside Diameter of the Tube or Pipe
0.125

Single Wall Thickness of Pipe or Tube
0.026

NOTE:
To determine Material Thickness at other locations,
Go to the bottom of the Trigonometry Page.

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Updated 3/24/99 by Derrill Rikard

HALF-VALUE LAYER / NARROW BEAM

HVL in CM	Linear Atten.in 1/CM
0.35	1.98

HVL in INCHES
0.14

TENTH-VALUE LAYER / NARROW BEAM

TVL in CM	Linear Atten. in 1/CM
10.10	0.228

TVL in INCHES
3.98

TYPICAL HALF-VALUE and TENTH-VALUE LAYERS in INCHES for COMMON ENERGIES

Energy	ALUMINUM 1/2	ALUMINUM 1/10	STEEL 1/2	STEEL 1/10	LEAD 1/2	LEAD 1/10
120 kV	0.800	2.640	0.100	0.330	0.011	0.036
150 kV	0.880	2.900	0.140	0.462	0.011	0.036
200 kV	1.000	3.300	0.200	0.660	0.019	0.063
250 kV	1.100	3.630	0.250	0.825	0.035	0.116
400 / Ir192	1.300	4.290	0.350	1.150	0.087	0.287
2 MeV / Co60	2.500	8.250	0.800	2.640	0.500	1.650
4 MeV	3.600	11.880	1.000	3.300	0.650	2.140
9 MeV	4.570	15.000	1.250	4.125	0.650	2.140

RADIOGRAPHIC EQUIVALENCE FACTORS

	Density of Fe or ?? in grams / cm^3	Linear Attenuation of Fe or ?? in 1/cm	Density of Material in grams / cm^3	Linear Attenuation of Material in grams / cm
Equal to this Thickness	7.87	0.334	16.6	0.73

of Fe or ?? Matl. by Method Listed Below

Thickness of Material: 1

2.109 Density Only
2.186 Linear Attenuation Only
4.610 Both Density & Linear Attenuation

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Updated 8/21/00 by Derrill Rikard

GEOMETRIC UNSHARPNESS

UG-in INCHES	Focal Spot Size in MM	Part Thickness + Offset	Source-Film-Distance
0.00168	2	6	288
INCHES Min. SFD	**MAX. UG Allowed**	**Focal Spot in MM**	**Part Thick + Offset**
17.748	0.02	4	2
SPOT Size in MM	**UG- in INCHES**	**SOD in INCHES**	**OFD in INCHES**
0.183	0.007874	8.25	9

OBJECT ENLARGEMENT

Object Size	Image Size	SOD	SFD
12.05	22.6	1.6	3
Image Size	**SFD**	**Object Size**	**SOD**
22.59	96	16	68
SFD	**Image Size**	**SOD**	**Object Size**
840.00	30	28	1
SOD	**SFD**	**Image Size**	**Object Size**
1.88	37.625	20	1

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Updated 2/25/99 by Derrill Rikard

COLLIMATOR LOCATION

SOURCE to COLLIMATOR DISTANCE	Source to Film Distance	SIZE of Collimator Image on Film	Collimator Hole Diameter
115.20	144	5	4
Collimator Hole Diameter	**SIZE of Collimator Image on Film**	**SOURCE to Collimator DISTANCE**	**Source to Film Distance**
4.00	12	96	288
SIZE of Collimator Image on Film	**Source to Film Distance**	**Collimator Hole Diameter**	**SOURCE to Collimator DISTANCE**
12.00	288	4	96

ADJUSTMENT for COLLIMATOR LOCATION

NEW FILM to COLLIMATOR DISTANCE	OLD FILM to COLLIMATOR DISTANCE	OLD IMAGE SIZE	IMAGE SIZE WANTED
90.00	72	4	5

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PARALLAX VIEWS or DEFECT LOCATION

Double Exposure made on ONE film which has been Shifted between Exposures.

RIGID FORMULA

Flaw Above Film	Flaw position change	Source to Film Dist.	Tube Shift
0.274	0.055	60	12

Double Marker Estimated Method - 2 markers are used and SFD and Tube Shift are Not Known.

Flaw Above Back Marker	Flaw Position Shift	Part Thickness	Front Marker Shift	Back Marker Shift
0.240	0.055	0.625	0.135	0.005

Defect Location from Front Surface using SOD and Front Marker Shift.

FRONT FACE to Flaw	Flaw Position Shift	Source to OBJECT	Front Marker Shift	Tube Shift
0.395	0.055	59.5	0.135	12

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MINIMUM & MAXIMUM FILM DENSITY for 1 PENETRAMETER
(All Film Densities must meet the CODE or SPECIFICATION)

MIN. Film Density	FILM DENSITY through the PENETRAMETER BODY & SHIM
1.96	2.3
MAXIMUM Film Density	THROUGH THE WELD'S AREA OF INTEREST
2.99	

Equivalent Penetrameter Sensitivity (Hole Type Penetrameter)

from: ASTM E-1025

EPS in percent	IQI Thickness in Inches	Hole Diam. in Inches	Material Thickness in inches
2.00	0.005	0.04	0.5
IQI Thickness In.	Hole Diam. in Inches	EPS in percent	Material Thickness in inches
0.005	0.04	2	0.5
Hole Diam. In.	IQI Thickness in Inches	EPS in percent	Material Thickness in inches
0.040	0.005	2	0.5

Equivalent Wire Diameter to Produce the Same EPS as the Hole Type Penetrameter from above

from: ASTM E-747

Equivalent Wire Diameter	Plaque Thickness in Inches	Hole Diam. in Inches
0.006	0.01	0.02

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TRIGONOMETRIC RATIOS on RIGHT TRIANGLES

SINE of ANGLE

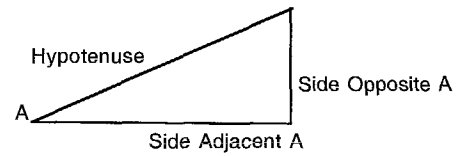
Angle A Degrees	Side Opposite A	Hypotenuse
0.333	0.25	43

TANGENT of ANGLE

Angle A Degrees	Side Opposite A	Side Adjacent A
0.199	0.25	72

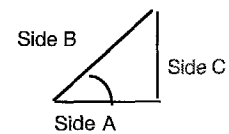
COSINE of ANGLE

Angle A Degrees	Side Adjacent A	Hypotenuse
18.407	40.8	43



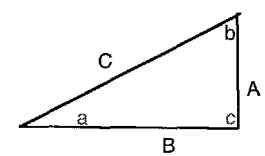
LAW of COSINES

Side C Length	Side A Length	Angle Between Sides	Side B Length
7.000	8	60	5



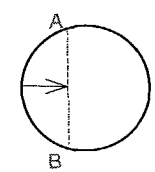
TRIGONOMETRY / LAW of SINES

Angle a	Angle b	Side A	Side B
20.71	50	1500	3250
Angle b	**Angle a**	**Side B**	**Side A**
49.98	20.7	3250	1500
Side A	**Angle a**	**Side B**	**Angle b**
1499.64	20.7	3250	50
Side B	**Angle a**	**Side A**	**Angle b**
3250.77	20.7	1500	50



CHORD LENGTH ON A CIRCLE

CHORD LENGTH	Distance From Outside Edge To The CHORD	DIAMETER of Circle
0.887	0.005	39.37



NOTE:

To determine thickness of a wall thickness on a tube or pipe,
Subtract the ID chord length from the OD chord length.

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COBALT Source Strength

COBALT	Original Activity	ON CAL.DATE	Present Date
671.44	1100	5/23/73	3/1/77

Radiation Output from COBALT

mR/Hr.	Source Strength-Ci.	Distance in FEET
1316.86	117.7	36
DISTANCE in FEET	Source Strength-Ci.	mR/Hr.
540.13	50.3	2.5
Source Strength-Ci	mR/Hr.	Distance in FEET
4.00	580	10

Approximate COBALT-60 Exposure Time in Minutes for a 2.0HD on 10pb/Dupont 55/10pb Film Load.

Time in Min.	Curies	Distance in Inches	Steel Thickness in Inches
2.31	100	24	2

IRIDIUM Source Strength

IRIDIUM	Original Activity	ON CAL.DATE	Present Date
41.96	100	9/9/88	12/12/88

Radiation Output from Iridium

mR/Hr.	Source Strength-Ci.	Distance in FEET
520000.00	100	1
DISTANCE in FEET	Source Strength-Ci.	mR/Hr.
29.94	100	580
Source Strength-Ci	mR/Hr.	Distance in FEET
100.00	208	50

Approximate IRIDIUM-192 Exposure Time in Minutes for a 2.0HD on 5pb/Dupont 55/10pb Film Load.

Time in Min.	Curies	Distance in Inches	Steel Thickness in Inches
14.52	200	48	2

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RADIATION INTENSITY

Second Intensity	Original Intensity	Linear Atten.in1/CM	Thickness in CM
0.168	18000	0.228	50.8

LINEAR ATTENUATION COEFFICIENT

Linear Atten. in 1/CM	Mass Absorption Coef.	Physical Density CC
3.287	0.279	11.78

AREAL DENSITY

AREAL DENSITY mg/cm2	Thickness in CM	Physical Density Mg/CC
59.69	1.27	47
Thickness in CM	**AREAL DENSITY mg/cm-2**	**Physical Density Mg/CC**
1.27	59.69	47
Physical Density Mg/CC	**AREAL DENSITY mg/cm-2**	**Thickness in CM**
47.00	59.69	1.27

RADIATION REDUCTION FACTOR

Reduction Factor	Dose Rate Wanted	Initial Dose Rate
90.00	0.5	45

PIN HOLE METHOD For FOCAL SPOT SIZE

Pin Hole Set at 1/2 the SFD

Focal Spot in IN.	Diam.of Hole Image	Actual Hole Diam.
0.045	0.125	0.04

Focal Spot in MM
1.143

Linear Attenuation Coefficient for Mixture

Lin.Atten Coeff 1/cm	Mass Atten Coef.1	Mass Atten Coef.2	Mass Atten 3	Mass Atten 4
0.006	3.8	5.91	65.4	0
	Per Cent 1	Per Cent 2	Per Cent 3	Per Cent 4
	75.6	23.1	1.3	0

DENSITY OF MATERIAL in GM/CC
0.001209

IN-MOTION RADIOGRAPHY

Motion Unsharpness	Material Thickness	Width of Beam	Source to Part Distance
0.004	0.5	0.3	42
Beam Width	**Motion Unsharpness**	**Material Thickness**	**Source to Part Distance**
0.42	0.005	0.5	42
Velocity	**Width of Beam**	**Time for Single Exposure**	
0.30	0.3	1	
Exp.TIME Min.	**Travel Distance**	**Velocity**	
33.33	10	0.3	

Exp.Time Hrs.
0.56

Film DENSITY vs. VELOCITY

NEW Velocity In/Min	Film DENSITY Wanted	First Film DENSITY	Old Velocity In./Min.
0.50	2	1	1

Volume of a Sphere

Volume	Sphere Diameter
0.0655	0.5

Area of a Circle

Area (Sq. Inches)	Circle Diameter (Inches)
0.0123	0.125

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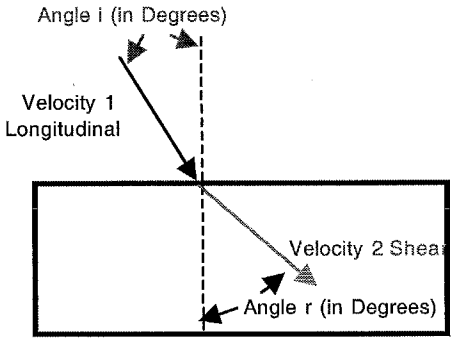
ULTRASONIC CALCULATIONS

SNELLS LAW

Angle i (in Degrees)	Angle r (in Degrees)	Velocity 1	Velocity 2
29.671	90	1.49	3.01
Angle r (in Degrees)	**Angle i (in Degrees)**	**Velocity 2**	**Velocity 1**
88.482	15.23	5.67	1.49
Velocity 1 Longitudinal	**Angle i (in Degrees)**	**Velocity 2**	**Angle r (in Degrees)**
1499.643	20.7	3250	50
Velocity 2 Shear	**Angle i (in Degrees)**	**Velocity 1**	**Angle r (in Degrees)**
3250.774	20.7	1500	50



Acoustic Impedance

Impedance-Z	Mat. Density g/cm 3	UT velocity
46800.000	7.8	6000

Amplitude / Decibels

Decibels	Amplitude 1	Amplitude 2
-6.021	20	40
Ratio A1/A2	**Decibels**	
17.783	25	

Wavelength

Wavelength	Velocity	Frequency
0.333	11	33

LENGTH of NEAR ZONE

Near Zone	Crystal Diameter	Wavelength
0.047	0.25	0.333

BEAM DIVERGENCE

Degrees 1 /2 Angle	Wavelength	Crystal Diameter	
1.679	1.2	25	
Degrees 1 /2 Angle	**Long.Velocity in MATL**	**Frequency**	**Crystal Diameter**
#DIV/0!			

REFLECTED ENERGY

Reflected Energy	Impedence 1 (Z-1)	Impedence 2 (Z-2)
0.233	2.3	6.6

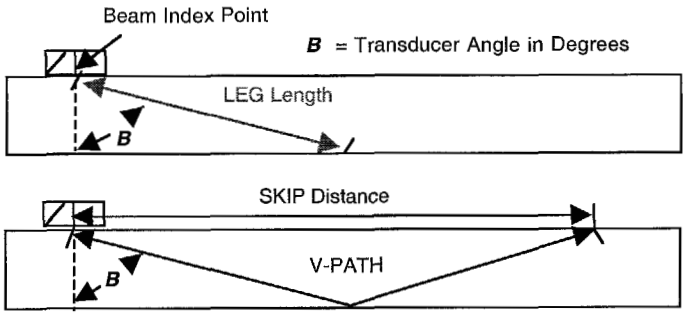
Beam Index Point

Angle Beam Formulae

	THICKNESS of MATL.	Transducer Angle in Degrees
LEG Length 1.414	1	45

	THICKNESS of MATL.	Transduce Angle in Degrees
V-PATH 2.828	1	45

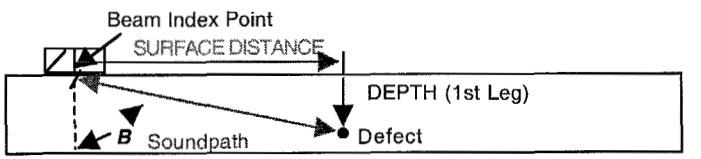
	THICKNESS of MATL.	Transduce Angle in Degrees
SKIP Distance 2.000	1	45



DEFECT LOCATION in 1st LEG

	Soundpath Distance	Transduce Angle in Degrees
SURFACE DISTANCE 1.414	2	45

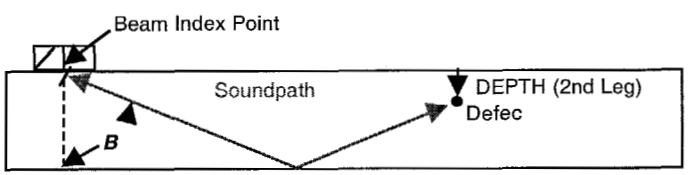
	Soundpath Distance	Transduce Angle in Degrees
DEPTH (1st LEG) 1.061	1.5	45



B = Transducer Angle in Degrees

DEFECT LOCATION in 2nd LEG

	THICKNESS of MATL.	Soundpath Distance	Transduce Angle in Degrees
DEPTH (2nd LEG) 0.586	1	2	45



B = Transducer Angle in Degrees

FIRST CRITICAL ANGLE

	Long. Vel. MAT.2	Long. Veloc. MAT.1
1st Crit. Angle Degrees 28.850	5.72	2.76

SECOND CRITICAL ANGLE

	Long. Veloc. MAT.1	Shear Veloc. MAT.2
2nd Crit.Angle Degrees 66.051	2.76	3.02